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The EUROPEAN CORN BORER and ITS CONTROL

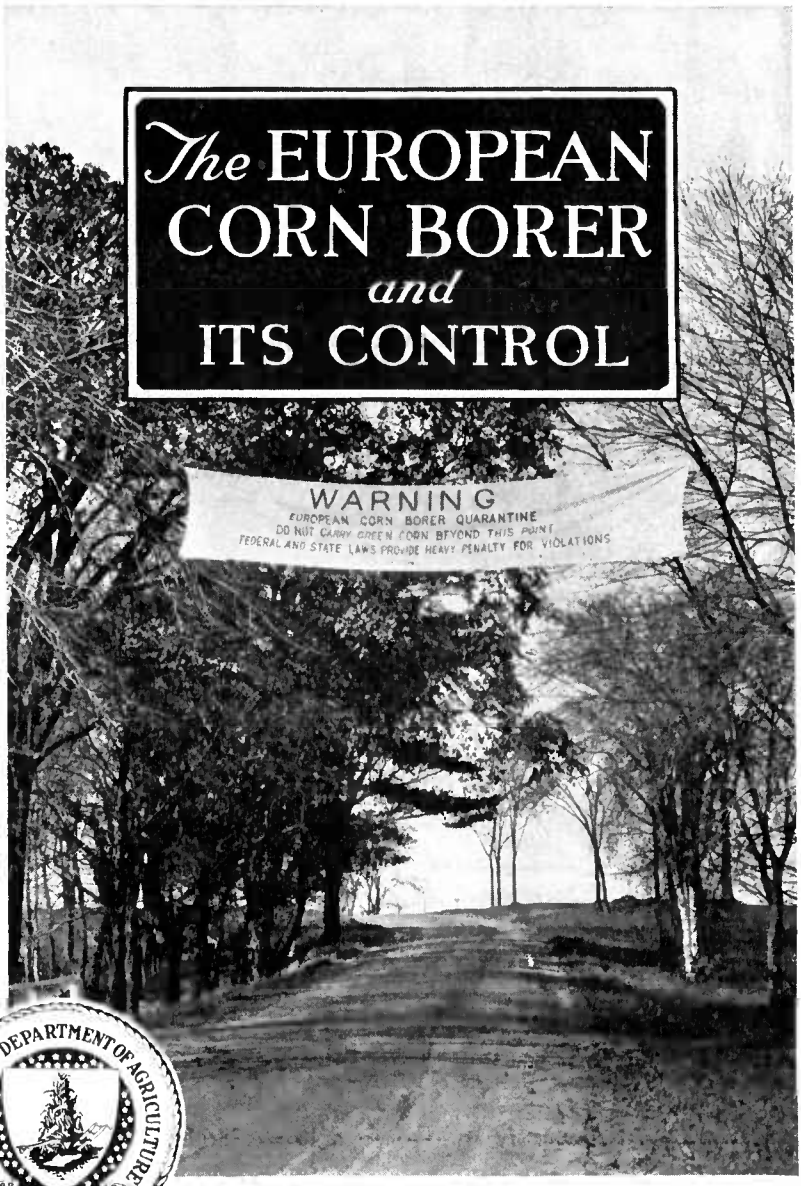

FIGURE 1.—Corn borer injury to various plants. Top at left: Larvæ and pupæ in cornstalks, and young tassel attacked by the insect. Male and female moths drawn on same scale as the corn. Top center: A female moth with cluster of eggs on a section of corn leaf, on a considerably larger scale. Top right: Mature tassel showing typical injuries by caterpillar (the broken tassel stem is often the most noticeable evidence of the presence of the insect during the early summer months). Center: External and internal views of injuries inflicted on two ears of sweet corn. Lower half of the figure: Snap beans, beets, and celery attacked by the borer, cornstalk containing caterpillars, corn stubbles cut away to show how the caterpillars hide themselves in the fall, winter, and early spring months, "smartweed," which is a favorite food at times, "barnyard grass," which in Massachusetts is often heavily infested, and "cocklebur" plant, a weed that often serves as a breeding place for the pest. (Walton.)

THE EUROPEAN CORN BORER[1] AND ITS CONTROL.

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CONTENTS.

A PEST OF PRIME IMPORTANCE.

THE EUROPEAN CORN BORER, the injurious stage of which is the young, or caterpillar, of a small moth, has become firmly established in the northeastern United States and in Ontario, probably having gained entrance in 1909 and 1910 in broom corn imported from Hungary and Italy. The results of four years of investigation by the Bureau of Entomology of this department leave no room for doubt that this insect constitutes a corn pest of prime importance. In addition, it attacks a large variety of useful and ornamental plants as well as grasses and weeds, and this increases its destructiveness and adds greatly to the difficulty of controlling it or restricting its spread. The losses resulting from the work of the insect have not as yet been extensive, but a gradual increase annually in such losses has occurred throughout all of the older areas of infestation in this country.

NOTE.—This bulletin is intended to supply practical information regarding the European corn borer to corn growers, corn canners, dealers in green vegetables, and market and home gardeners. Complete technical details regarding the Federal investigations of the corn borer will be supplied in a subsequent publication.

[1] *Pyrausta nubilalis* Hübn.; order Lepidoptera, family Pyralidae, subfamily Pyraustinae.

The discovery, in August, 1921, of a slight but extensive infestation of the pest along the southern shore of Lake Erie in Pennsylvania, Ohio, and Michigan indicates that this insect is about to invade the area of most intensive corn production, and that steps to combat the pest must be taken promptly if future losses from its work are to be prevented or overcome.

HISTORY OF THE INSECT IN THE UNITED STATES.

During the summer of 1917 the European corn borer (Fig. 1) was first reported and identified from the United States.[2] At that time it was found to be causing severe damage to sweet corn in the vicinity of Boston, Mass., and to be present within an area of at least 100 square miles in that section.

In January, 1919, the insect was discovered in the vicinity of Schenectady, N. Y., and in September, 1919, separate infestations were found south of Buffalo, N. Y., and at Girard, Pa.

The summer scouting of 1921 revealed an infestation of the pest on Middle Bass Island in Lake Erie, not far from the Ohio shore. Subsequent investigations showed that a sparse but extensive infestation occurred throughout a narrow strip of territory comprising most of the towns bordering Lake Erie, and adjacent thereto, in the States of Pennsylvania, Ohio, and Michigan.

DISTRIBUTION IN NORTH AMERICA.

UNITED STATES.

To date the European corn borer is known to be present in three separate areas in the United States (Fig. 2) comprising a total area of 7,696 square miles.

The most severely infested area is in New England and contains 2,670 square miles including 140 towns in eastern Massachusetts and 12 towns in southeastern New Hampshire. This area extends along the Atlantic coast and a short distance inland. (Fig. 2, *a*.)

In eastern New York 64 towns and cities, containing 2,203 square miles, are known to be infested. This area is in the section surrounding Schenectady. (Fig. 2, *b*.)

The third and largest area of infestation is in the territory along the American shore of Lake Erie, and probably extends only a short distance inland. This includes 44 towns in western New York, comprising an area of 1,634 square miles, 12 townships and cities in northwestern Pennsylvania, with an area of 347 square miles, 30 townships in northern Ohio, with an area of 757 square miles, and 3 townships in southeastern Michigan with an area of 85 square miles. (Fig. 2, *c*.)

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[2] In August, 1916, specimens of dahlia stems infested by caterpillars of some moth were sent to the Massachusetts Agricultural Experiment Station, Amherst, Mass., from three localities near Boston, Mass. Adults were reared from this material, but the fact that they were the European corn borer was not established until after adults had been reared and identified from sweet corn in 1917.

Extensive scouting operations have been carried on during the past three years in the territory surrounding and adjacent to the infested areas of New England, New York, Pennsylvania, Ohio, and Michigan, as well as along the main lines of travel, river valleys, water routes, the vicinity of broom factories, and other susceptible localities in those States. Scouting operations have included field examinations in susceptible localities not only in the territory east of and including the Mississippi River basin States, but also in Texas, New Mexico, and Arizona. Particular attention has been given localities where imported broom corn was known to have been re-

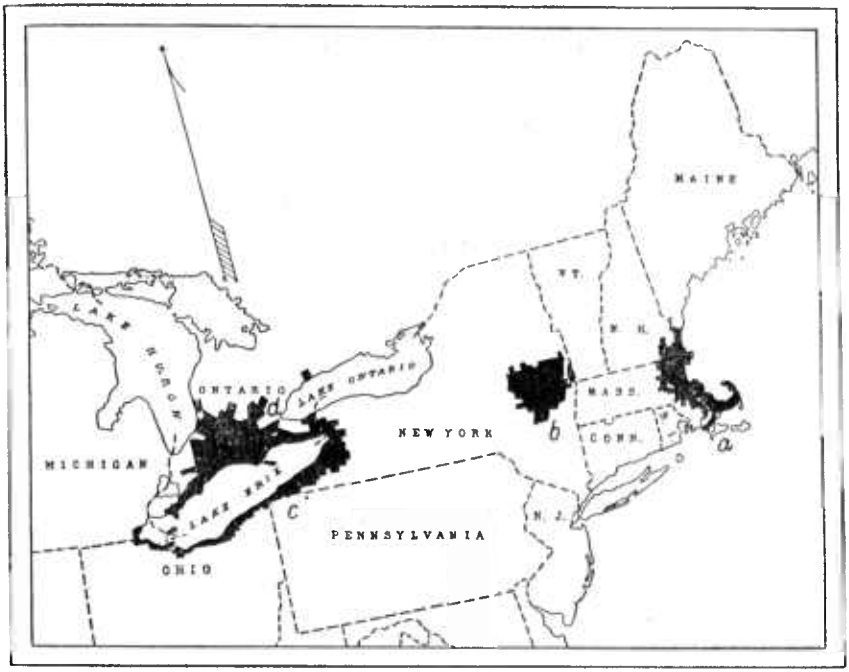

FIG. 2.—Map showing areas of infestation of the European corn borer in North America, as known April 1, 1922: *a*, New England area; *b*, eastern New York area in vicinity of Schenectady and Albany; *c*, western New York area, including Buffalo and Dunkirk, and the spread of 1921 in Pennsylvania, Ohio, and southeastern Michigan; *d*, Canadian areas of infestation.

ceived, as well as to sections producing field corn, sweet corn, and broom corn. Special scrutiny has been given the territory adjacent to ocean and river ports as well as railroad centers, and along the main railroad, highway, and water routes.

DOMINION OF CANADA.

During August, 1920, the Canadian authorities reported an infestation in Welland County, Ontario, bordering the Niagara River from the western New York area of infestation, and another large and heavily infested area extending along the Canadian shore of Lake Erie with its apparent center near St. Thomas, Ontario. (Fig. 2, *d*.)

Recent advices from the Canadian authorities report the European corn borer as present in an area of about 7,690 square miles, comprising most of the southern Ontario peninsula bordering Lake Erie and including Pelee Island. The infested area extends on the north to Goderich on Lake Huron, and on the east to Lake Ontario and the Niagara River. There is also a small isolated infestation on the northern shore of Lake Ontario.

PROBABLE METHOD OF INTRODUCTION.

The exact date and manner in which this European pest gained entrance to the United States is not definitely known, but circumstantial evidence accumulated since its discovery indicates strongly that broom corn imported from Hungary and Italy in 1909 and 1910 was the carrier. Broom factories which received this foreign material were located near the centers of infestation at Everett, Mass., and Amsterdam, N. Y. An apparent confirmation of this probable method of introduction was afforded when two shipments of broom corn, received at the port of New York from northern Italy during February and March, 1920, were found to be infested and shipments received from Hungary during April, 1922, were found to be similarly infested. Broom corn is commonly infested by this insect in Europe.

Raw hemp formerly was believed to be the most likely medium through which the insect gained entrance to this country, but this theory has been abandoned.

From present indications it is believed that the infestations on the islands and along the shore of Lake Erie in Michigan, Ohio, and Pennsylvania may have originated from the badly infested area just across Lake Erie, in the Province of Ontario. The history and intensity of this Canadian infestation indicate that it is probably the oldest colony of the pest in this region. The infestation in western New York may also have originated from the same source, although the origin of this infestation is more obscure. The method of dispersion from Ontario may have been by forced flight of the moths or by the drift of infested plant material in the waters of Lake Erie; at the present writing, however, no traces of such material have been discovered. A study of the wind and water currents in the Lake Erie section, in conjunction with the known habits of the insect, shows the possibility of such dispersion through either of these agencies. Recent experiments have shown the moth to be capable of a flight of nearly 20 miles.

PLANTS ATTACKED BY THE INSECT IN THIS COUNTRY.

Corn is injured by the larvæ, or borers, of the European corn borer to a greater extent than any other cultivated crop attacked by the insect in this country. The borer attacks sweet corn, field corn (both dent and flint), pop corn, and corn planted for fodder or silage. Corn doubtless is the preferred host of the insect in North America, as it is in Europe. In the badly infested area in New England the borers also attack a variety of other plants, including field crops, vegetables, flowers, grasses, and weeds. (Fig. 1.)

The economic plants (other than corn) attacked by the insect in New England may be roughly divided into two groups, according to their susceptibility as recorded at this writing. Only the more important economic plants are listed.

GROUP I.—*Economic plants frequently attacked by the European corn borer.*

Aster.	Chrysanthemum.	Hemp.	Sunflower.
Barley.[3]	Cotton.[3]	Hops.	Swiss chard.
Beans.	Cowpea.[3]	Millet.	Sweet sorghum [3]
Beets.	Dahlia.	Peppers.	
Broom corn.[3]	Gladiolus.	Potato.	
Celery.	Grain sorghums.[3]	Rhubarb.	

GROUP II.—*Economic plants occasionally attacked by the European corn borer.*

Artichoke.	Golden glow.	Okra.[3]	Sweet clover.
Buckwheat.[3]	Hollyhock.	Parsnip.	Timothy.
Calendula.	Johnson grass.[3]	Salvia.	Tobacco.[3]
Canna.	Marigold.	Soy bean.[3]	Tomato.
Cosmos.	Mignonette.	Spinach.	Zinnia.
Geranium.	Oats.	Sudan grass.[3]	

The infestation of these crops, other than corn, is especially likely to occur (1) when corn is growing near by; (2) when the infested crop remnants and weeds from previous crops on the same, or adjacent, areas have not been destroyed; and (3) when susceptible weeds are growing in the same field or in its immediate vicinity.

Many of the thick-stemmed weeds and grasses serve as hosts of the borer in the New England area of infestation, and aid in its multiplication as well as complicating its effective control. Among these plants are included barnyard grass,[4] cocklebur,[5] smartweed,[6] pigweed,[7] ragweed,[8] beggarticks,[9] dock,[10] panic grass,[11] burdock,[12] horseweed,[13] tansy,[14] wormwood,[15] and other similar plants. These susceptible weeds are often very heavily infested in some of the cultivated fields and waste places. Occasionally the borers appear to prefer these plants as hosts rather than corn.

In New York, Pennsylvania, Ohio, and Michigan the infestation to date has been confined mostly to corn, with a light infestation in the more susceptible weeds. In western New York a very few borers have also been found in some of the cultivated crops and flowering plants (soy beans, sorghum, millet, dahlia, and cosmos). It is probable that the degree and variety of infestation in susceptible weeds, vegetable crops, field crops, and flowering plants will increase if the insect becomes more numerous in these areas.

To date (January 1, 1922) the European corn borer has been found in 185 species and varieties of plants in the United States. Some of these plants undoubtedly serve primarily as shelter for the borers rather than as food.

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[3] Plants occurring rarely in the infested portion of New England or which were grown only in the experimental fields.

[4] *Echinochloa crus-galli.*
[5] *Xanthium* spp.
[6] *Polygonum* spp.
[7] *Amaranthus retroflexus.*
[8] *Ambrosia* spp.
[9] *Bidens* spp.
[10] *Rumex* spp.
[11] *Panicum* spp.
[12] *Arctium* spp.
[13] *Erigeron canadensis.*
[14] *Tanacetum vulgare.*
[15] *Artemisia* spp.

The egg clusters of the insect have also been found in the field on dandelion,[16] horseradish,[17] lettuce,[18] oxalis,[19] plantain,[20] and rye.[21] Borers have been reared experimentally upon these plants and also upon blue-grass.[22]

CHARACTER OF INJURY TO CORN.

The most serious injury caused by the European corn borer to corn is through the work of the larvæ, or borers, in the ears and stalks. The borers also tunnel within the tassel, the midrib of the leaf, the brace roots, the stubble, and in fact all parts of the corn plant except the fibrous roots. In addition they often feed to a slight

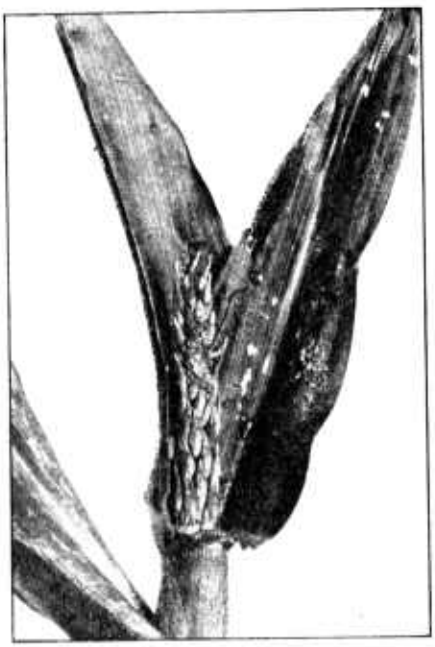

FIG. 3.—Newly developed tassel of corn plant, showing injury by young larvæ of the European corn borer. Note small gnawed areas on leaves at right caused by feeding of newly hatched larvæ.

FIG. 4. Broken corn tassel showing injury caused by larvæ of the European corn borer (Caffrey.)

extent upon the surface of the plant, particularly upon the leaf blades (Fig. 1), the tassel buds, the husks and silk of the ear, and between the leaf sheath and the stalk.

The character of the injury to corn depends upon the stage of growth of the plant when attacked, and also upon the habits of individual borers. Usually, however, the newly hatched borers feed for a short period upon the surface of the plant, near their place of hatching, particularly upon the tender leaf blades (Fig. 3), or upon the green silk and husk of partially developed ears.

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[16] *Leontodon* spp.
[17] *Radicula armoracea.*
[18] *Lactuca sativa.*
[19] *Oxalis* spp.
[20] *Plantago* spp.
[21] *Secale cereale.*
[22] *Poa pratensis.*

Within a few hours after hatching many of the borers begin to migrate to various parts of the same plant or to other plants in the

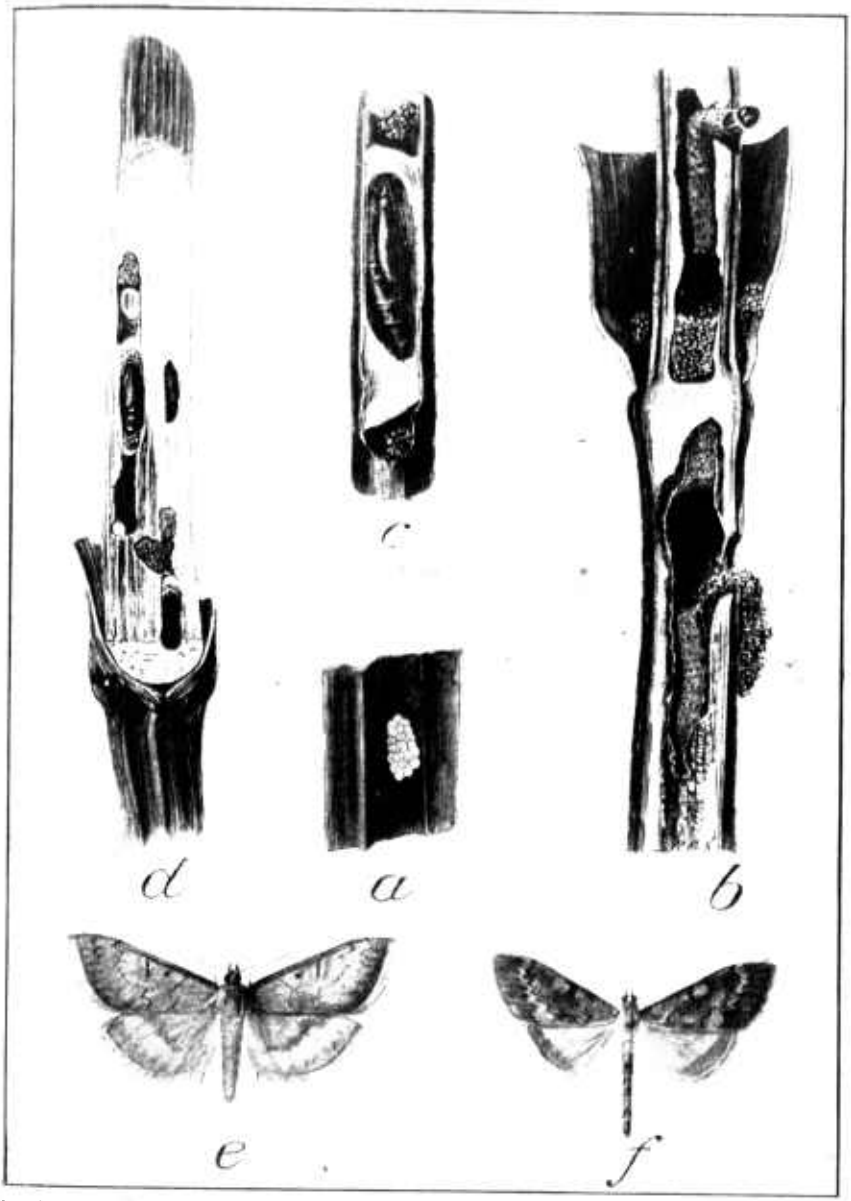

FIG. 5.—The European corn borer: *a*, Eggs; *b*, cornstalk sectioned to show larvæ in their burrows; *c*, cornstalk sectioned to show pupa inclosed within pupal chamber; *d*, cornstalk sectioned to show pupa inclosed within pupal chamber in dry cornstalk; *e*, female moth; *f*, male moth. All somewhat enlarged.

vicinity. If the attacked plant is just developing a tassel, some of the small borers enter the tassel buds and feed within (Fig. 3) while

others feed on the surface of the tassel buds and protect themselves with a slight silken web.

As the tassel develops and the feeding borers become larger, they tunnel within the tassel stalk and its branches. This injury so weakens the tassel stalk that it frequently breaks over. Such broken tassels (Fig. 4), with extrusions of frass or sawdust-like material at the breaks, are the most conspicuous signs of infestation in fields of growing corn. Field counts made in badly infested cornfields have shown as high as 80 per cent of such broken tassels. Certain corn plants, especially when attacked during an advanced stage of their growth, do not always exhibit this particular type of injury.

FIG. 6.—Portion of cornstalk showing external evidence of the work of the European corn borer. (Caffrey.)

After working in the tassel stem, the borers may continue tunneling downward into the main stalk (Fig. 5), or they may leave the upper part of the plant and enter it, or neighboring plants, at points lower down (Fig. 5), gradually increasing the size of their tunnels as they develop, and working upward or downward, according to their individual preferences. Small holes in the plant with sawdust-like extrusions (Fig. 6) indicate where the borer is at work.

Instead of feeding upon or within the tassel buds and tassel stalks, some of the newly hatched borers habitually migrate to points lower down on the plant. Under these circumstances they may enter

the plant at practically any point, but usually enter between the leaf sheath and stalk (Fig. 6), or between the stalk and the base of the partly developed ear (Fig. 7), in case the plant has advanced to that stage of growth.

Where, as frequently occurs, several or many borers are present within the same stalk, it becomes reduced to a mere shell, filled with

FIG. 7.—External view of ear, showing extruded frass and numerous punctures caused by larvæ of the European corn borer. (Caffrey.)

fragments of the frass or castings of the borers. Such injury may cut off much of the supply of nutriment from the developing ear and greatly weaken the stalk, which eventually collapses and breaks over.

The ears are entered by the borers either directly through the silk and husk, or through the short stem or "shank" by which the ear is attached to the plant (Fig. 8). Here they feed upon the grain

and tunnel through all parts of the cob. The "shank" of the ear often is thoroughly tunneled by the borers. Such injury, where extensive and occurring before the ear is well developed, may result in a small or poorly formed ear. This type of injury may cause the ears to break off and fall to the ground before harvest.

In the New England area, during July and August, many of the moths deposit their eggs directly upon, or closely adjacent to, the newly developed ears of late corn. Many of the resulting borers feed at first upon the silk, and then enter the ears directly, where

FIG. 8.—Longitudinal section of ear of sweet corn damaged by European corn borer, showing entrance of larva, the stem, and cob. (Caffrey.)

they feed voraciously upon the grain and cob. It is at this time that the borers do the greatest amount of damage to the ears. As many as 15 full-grown borers, each about an inch long, have been found feeding upon and within a single ear of corn.

The injury to stalks and ears may be further increased by a soft rot which sometimes follows the work of the borers and reduces the

interior of infested plants to a decaying, putrid mass. This rot may cause greater loss than is occasioned primarily by the work of the borers.

CHARACTER OF INJURY TO PLANTS OTHER THAN CORN.

The injury to plants other than corn is of the same general character as that to corn, except that in some instances special parts of the plants appear to be preferred as food or shelter.

The stems or stalks of celery, rhubarb, potato, hops, oats, barley, buckwheat, hemp, cotton, dahlia, chrysanthemum, gladiolus, aster, zinnia, cosmos, geranium, and others are entered and tunneled by the borers, and the larvæ are sometimes found in the fruits or flowers of certain plants, notably tomato, pepper, cotton, hemp, dahlia, chrysanthemum, and gladiolus.

The stem and leaves of beets, spinach, Swiss chard, and others are preferred by the borers when attacking these plants.

In beans the borers are usually found in the stalks, pods, or green beans.

In addition to the actual loss caused by the work of the borers in these crops, there is also the liability that such products, when distributed through commerce, may contain the insect and thus serve as carriers of the pest to new localities.

Injury to the weeds and wild grasses (Fig. 1) serving as hosts of the European corn borer is not of itself commercially important, but the presence of such weeds and grasses affords abundant opportunity for the multiplication and spread of the pest throughout areas where corn is not grown. In cultivated fields the borers are sometimes so numerous that they are compelled to feed upon these other plants in order to complete their growth. There is also a possibility that some of these wild plants, when used for packing material or as bedding, may contain the borers and thus become a medium for transporting the pests to new localities.

EXTENT OF INJURY TO CORN.

NEW ENGLAND.

In this area the cultivated ground within a radius of about 15 miles of Boston consists very largely of truck and market-garden farms, many of which have been reclaimed from tidal swamps. The soil in many cases is a dark, heavy one, abundantly supplied with humus and moisture. There are in addition some uplands scattered throughout the area where truck crops and corn are grown, but in no case is there any considerable area where field corn is grown on a large scale, as is commonly the case in the Corn Belt, or even throughout the general farming areas of the United States. Thousands of suburban kitchen gardens are also involved in this region.

Because of the damp climate, the excellent growing conditions, and the lush character of the vegetation, this area affords exceptionally favorable conditions for the existence and rapid multiplication of the corn borer. Neglected fields, city lots, and uncultivated areas abound, very often thickly covered with large herbaceous plants and weeds, in which the corn borer is permitted to breed unmolested, and

it makes the best of this opportunity. It should be understood also that the infestation of the pest throughout even this old and intensely infested region is not uniform but that the more heavily infested areas occur in spots more or less scattered. No fields of dent corn are grown commercially in this area.

Although a very small amount of flint and no dent corn is grown for grain within that portion of Massachusetts where the corn borer has existed for at least a decade and become well established during that time, both types of corn are readily attacked by the borer, judging from observations made in the few commercial fields of flint corn available and the experimental plats which contained representative varieties of both dent and flint corn. The experimental plats in which this corn was grown were situated in three different sections of this heavily infested region, and it is believed that the results there obtained represent average conditions of infestation and injury which may be expected to occur in similar localities where the insect is fairly abundant and has become well established.

In this heavily infested area it was found that slightly more than four-fifths of the ears of flint corn (Figs. 9, 10) were infested with the borer, with a damage to the grain on these infested ears amounting to approximately one-eighth of the grain produced. Dent corn grown experimentally within this same area was found to be somewhat less injured by the attack of the borer, approximately three-fourths of the ears being infested, while only 2 per cent of the grain was found to be damaged. Sweet corn (Fig. 11) grown in this area and representing average conditions was found to be infested to such an extent that slightly more than half of the ears contained the borer at the time of picking, while in many of the smaller and more intensely infested fields every ear was found to have the borer present. Although the grain on many of the infested sweet-corn ears was only damaged to a slight extent, this slight injury was sufficient to render the majority unfit for market purposes and in consequence of this injury there resulted an average loss of slightly more than one-third of the total value of the crop in 16 of the more heavily infested fields.

The infestation and injury to sweet corn and to early maturing varieties of flint (field) corn in practically all cases have been more severe than in the larger and later maturing varieties of dent (field) corn. In some instances, however, the insect appeared to exhibit an equal preference for sweet, flint, and dent corn. In these cases the choice apparently depended more upon the stage of development of the plant, or upon its proximity to infested weeds or other plant material, than on the type of corn.

During 1921, which was an unusually favorable season for caterpillar enemies of corn, the resulting damage by the corn borer was somewhat increased over the preceding season, more markedly, however, in towns situated at some distance from the center of the infestation, and it may be of interest at this point to illustrate by a specific example the representative conditions which existed in the most heavily infested fields of sweet and field corn. In a very heavily infested 1-acre field of Longfellow flint corn, every stalk of corn in the field contained the borer, with an average of 11 borers to the stalk. The ears were nearly as highly infested as were the stalks, 96 per cent containing borers, with an average of 3 borers to each infested ear.

Outside of this area which has just been discussed, and even in some fields within it, little or no economic damage has occurred to either sweet or field corn, owing to the light character of the infesta-

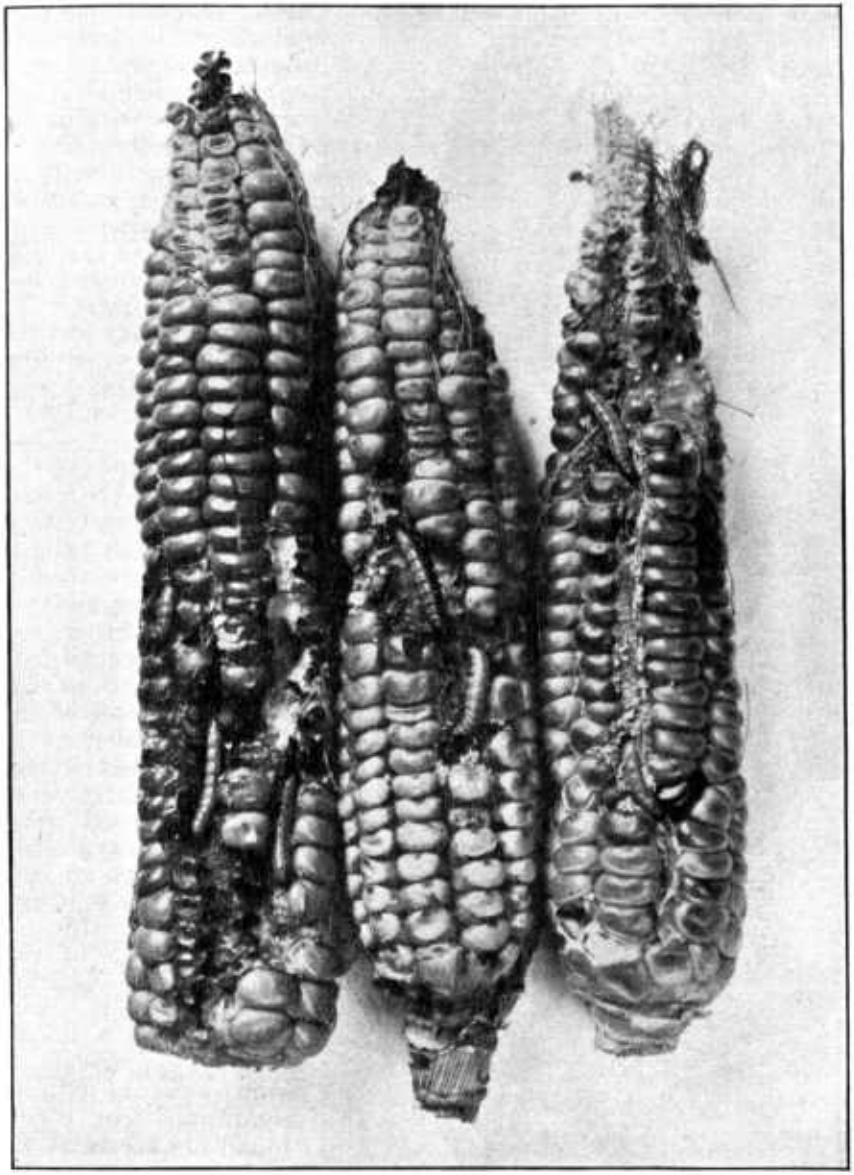

FIG. 9.—Typical injury by the European corn borer to the grain on the immature ears of flint (field) corn. Borers are shown feeding in natural position. The interior of the cobs was also badly tunneled by the borers.

tion and possibly to the clean-up methods which have been employed by the State and Federal authorities, as well as by farmers, gardeners, and other interested persons.

NEW YORK.

In this region of the corn-borer infestation the extent of injury and economic loss caused by the European corn borer to date has been comparatively slight. The injury and loss, as well as the degree of infestation, however, have been greater in the western than in the eastern area of the State. An intensive clean-up campaign in eastern New York by the State authorities soon after this infestation was discovered may also have aided in preventing the increase of the pest which otherwise might have occurred.

FIG. 10.—Mature ear of flint corn, showing damage by the European corn borer.

In the western area of the infestation, near Lake Erie, sweet corn is infested to a slightly greater degree than are the various varieties of flint and dent corn in the most heavily infested fields, while in sections which represent the average conditions of infestation sweet corn is approximately twice as heavily infested as are the field-corn types (dent or flint). Sweet corn representing average conditions in this area has an average of about one-tenth of the stalks containing the borer, while 3 in each 100 ears are unfit for market. In comparison with this condition, dent corn is found to have an average of 5 per cent of the stalks infested, while but 1 ear in 100 contains the borer. However, in the most heavily infested sections, sweet corn has an average of slightly less than 25 per cent of the stalks infested, with an occasional maxi-

mum of approximately 50 per cent. Under these conditions an average of 5 per cent of the ears have been found unmarketable. Dent corn under like conditions averages 18 per cent stalk infestation.

In the eastern New York area the comparative infestation between sweet and field corn is the reverse of that found in the western area, although the difference is very slight. An average of 3 per cent more of the stalks were infested in dent than in sweet corn in this area, considering representative fields in making this statement.

In this area sweet corn contains an average of slightly less than 6 per cent of the stalks and 3 per cent of the ears infested, while dent and flint corn have an average infestation in the stalks amounting to 7 per cent and with only 1 per cent of the ears containing the borer.

FIG. 11.—European corn borer larva feeding in ear of mature sweet corn. Slightly larger than natural size.

The grain injury by the borer in New York has been slight. In the most heavily infested section of the western area, from 3 to 5 per cent of the grain was damaged, with a few cases where the injury amounted to approximately 16 per cent in sweet corn. In one of the worst infested fields of field corn the damage amounted to 3 per cent of the kernels destroyed. In the eastern area an average of less than 1 per cent of the ears of sweet corn were rendered unmarketable by the borer and the damage to field corn was slightly less. During the favorable season of 1921, however, the grain injury in one case amounted to an average of 7 per cent damaged kernels and in sweet corn an average of 13 per cent was noted.

PENNSYLVANIA, OHIO, AND MICHIGAN.

At the present writing there has been no appreciable damage by the European corn borer in the newly infested cornfields of this section of the infested area, owing to the slight character of the infestation in these recently invaded regions.

INDIRECT INJURY.

The foregoing estimates of injury to the ears and grain refer only to the direct injury through the attack of the borer to the corn ear. In addition to this direct loss there is an indirect loss of grain in badly infested plants caused by the tunneling of the insect in the

stalk below the ear and especially in the short stem or shank bearing the ear. This injury (which of course prevents the proper food supply from reaching the developing ear), where severe and occurring before the ear is well developed, frequently results in a small and poorly formed ear. These injuries not only reduce the supply of nourishment for the growing ear, but in many cases weaken the stalk and shank to such an extent that the occurrence of heavy winds or severe rainstorms subsequently results in extensive breaking over of the stalks and ears. The ears thus thrown to the ground may subsequently be injured or destroyed by rots and molds during ensuing wet weather. Severe injury to the stalk, besides weakening and preventing its proper development, offers an excellent opportunity for the ingress of plant diseases and various rots, molds, and fungi. In cases where severe injury to the tassels or male flowers has resulted in a large percentage of them breaking over, inadequate pollinization of the ears may occur and thus result in the diminishing of grain formation.

The actual grain loss resulting from this indirect injury to the ear is difficult to estimate, as it varies greatly in different fields and depends upon several factors, the most important of which are (1) the number of borers per plant; (2) the stage of development of the plant when attacked; (3) the part of the plant selected for attack. In general, however, it may be stated that in very badly infested fields the indirect loss may nearly or quite equal the direct loss sustained by the feeding of the borers on the grain.

EXTENT OF INJURY TO VEGETABLES, FLOWERS, AND FIELD CROPS OTHER THAN CORN.

No instances of infestation in cultivated plants except corn have been observed to date in eastern New York, Pennsylvania, Ohio, and Michigan, although in western New York an occasional borer has been found in experimental areas of millet, sorghum, soy beans, dahlias, and cosmos. A single commercial field of soy beans was also found to be slightly infested.

The extent of injury to vegetables, flowers, and field crops in New England as a direct result of the feeding of the borers is not severe in most instances. Some of these crops which are quarantined, however, especially celery, beans, beets, rhubarb, and spinach, suffer an indirect loss through the restriction of the area in which they may be marketed. This loss for individual growers has amounted in certain seasons to a maximum of 20 per cent of the total value of the crop. In many home vegetable and flower gardens, the feeding of the borers in potato stalks, tomato stalks and fruit, Swiss chard, pepper stalks and fruit, dahlias, asters, zinnias, and similar plants caused considerable loss in the aggregate, but the exact amount involved is difficult to determine. The injury to corn is, of course, the most important consideration in the corn-borer problem, but the extent of infestation in marketable products of other economic crops is also important, because they may contain the insect and serve to carry it to new areas.

During the exceptionally favorable growing season of 1921 there was an increased amount of infestation and injury to some of the

vegetable and flower crops, but the economic loss, as a direct result of the feeding of the borers in any instance, seldom exceeded 1 per cent of the value of the crop. The insect was present in nearly every commercial field of rhubarb, beets, celery, and beans examined in the infested area in Massachusetts during this season, the degree of infestation ranging from 1 to 75 per cent. The worst affected portions were usually found in weedy fields and along field borders, where the plants were growing among or in close proximity to infested weeds or corn.

In order to present a general idea of the damage to the plants concerned, and the commercial loss sustained due to the attack of the borer, the following list of plants, with a brief mention of the extent of injury and intensity of attack, will suffice.

RHUBARB.

Affected to a greater extent than any other vegetable or garden crop, excepting sweet corn. Eggs of both generations found on leaves. Borers tunneled in the leaf stalks, seed stalks, and veins

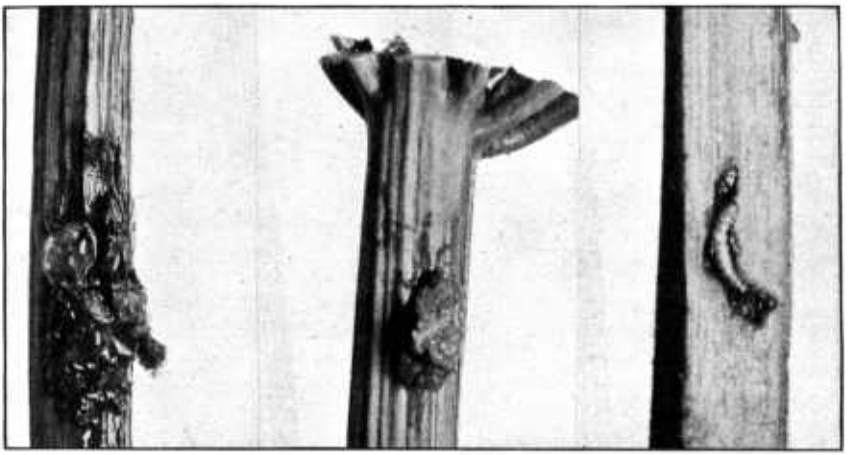

FIG. 12.—Rhubarb stems infested with the European corn borer.

of leaves and frequently caused them to collapse and break over. Injury occurred after close of commercial season and growth of plants did not appear to be seriously affected. (Fig. 12.)

BEETS.

Similar to that outlined under rhubarb. Borers tunneled extensively in leaf stalks and infrequently entered the beet root. Injury did not appear to seriously interfere with the growth of the plant. (Fig. 13.)

CELERY.

Infestation light, but quite general. A few egg clusters found on leaves. Borers tunneled in the leaf stalks and in cases of severe injury the affected parts were unfit for sale. Affected portion usually could be removed with very little commercial injury to the rest

of the plant. In the worst infested field noted there was an average of 2 per cent of the plants infested, with a maximum of 60 per cent in the worst affected portions. (Fig. 14.)

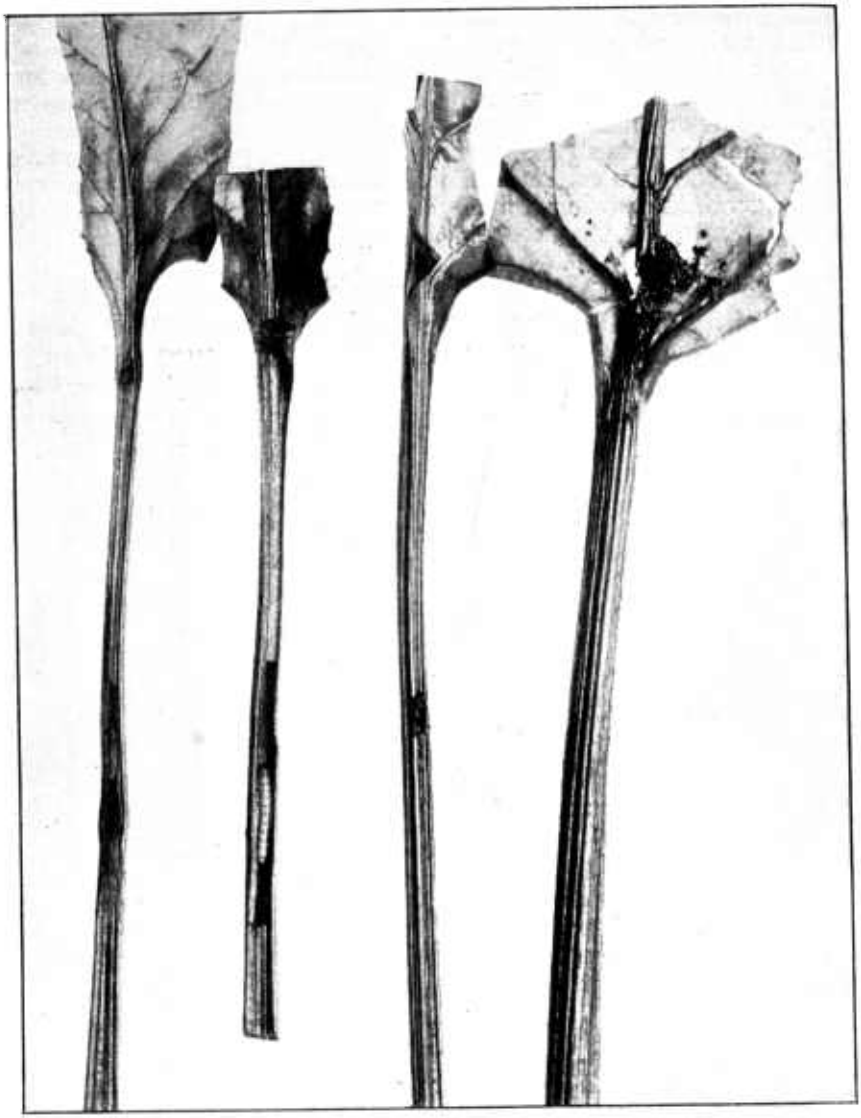

FIG. 13.—Beet stems injured by larvæ of the European corn borer.

BEANS.

Confined principally to stalks with an occasional borer in the pods. Egg clusters were found rather infrequently on the leaves from the first week in July to the last week in August. Borers tunneled in stalks and as a result of severe injury breaking over of the affected

parts resulted. Very little commercial injury. Less than 1 per cent of the pods were infested in any of the fields under observation. (Fig. 15.)

SPINACH.

A few egg clusters have been found on the leaves each year. Less than 1 per cent of the plants were infested in any case and no appreciable loss resulted.

PEPPERS.

Injury to both stalks and fruit of "sweet" and "hot" varieties. Injury to stalks in some cases caused a reduction in yield, since stalks

FIG. 14.—Stalk of celery injured by the European corn borer. Side of stalk cut away to show borer within. (One-half natural size.)

were broken over before fruit had fully developed. Some fruit was unfit for sale. Estimated loss in worst infested commercial gardens was 5 per cent of value of crop.

DAHLIAS.

Most susceptible of flower crops. Borers tunneled extensively in stalks. Injury resulted in the breaking over and wilting of plant before flowers had attained full development. No infestation in

bulbs recorded. Worst affected gardens had 100 per cent of stalks infested. Estimated loss to commercial gardens 5 per cent of value of crop.

ASTERS.

China or garden asters were generally very heavily infested both in home and commercial gardens including both those grown outdoors and to a lesser extent those propagated in greenhouses. Borers tunneled in main stems and flower stalks causing mutilation of plants in heavily infested plantings. Injury often prevented normal development of flowers. Estimated loss in heaviest infested fields ranged from 10 to 15 per cent of total value of crop.

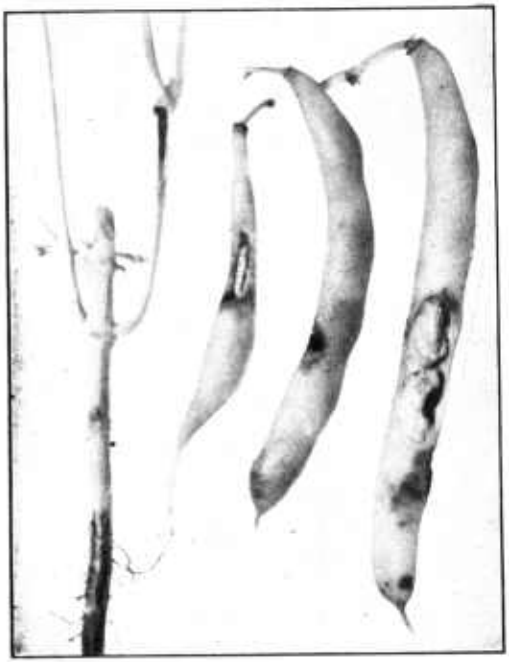

FIG. 15.—Green beans showing the work of European corn borer larvæ.

CHRYSANTHEMUMS.

Infestation confined principally to plants grown under glass. Usually less than 1 per cent of plants injured, although, in a few cases noted, infestation amounted to 10 to 20 per cent. Injury to flower stem often prevented proper development of blooms. Estimated loss in worst infested greenhouses amounted to 2 per cent of total value of crop. (Fig. 16.)

GLADIOLI.

Infestation usually amounted to only a trace, except that in one case where plants were growing near other infested plants a maximum of 6 per cent infestation was recorded. Egg clusters found on leaves. Few borers present in flower stalks. Losses trivial. (Fig. 17.)

ZINNIAS.

Frequently found infested in home gardens and small commercial gardens. Infestation varied from a trace to 10 per cent. Injury seldom interfered with normal development of flowers, except in a few cases. Losses in any instance did not exceed 1 per cent of value of crop.

COSMOS AND HOLLYHOCKS.

The stalks of cosmos and the flower stems and leaf stems of hollyhocks occasionally found infested. No appreciable loss.

OATS.

Stems have occasionally been found infested when plants were growing as volunteers in waste places or among other crops. Detailed examinations of oat straw grown experimentally within the infested area also revealed borers present in both baled and loose straw at the rate of 8 borers to 100 pounds of baled straw and 11 borers to 100 pounds of loose straw. (Fig. 18.)

SEASONAL HISTORY AND HABITS.

There are usually two complete generations annually of the European corn borer in the New England area of infestation, according to observations made since the discovery of the insect in 1917. This habit is subject to some variation, however, in accordance with seasonal climatic fluctuations. In 1920 only one complete generation and a partial second generation were produced, while in 1921 two complete generations and a partial third generation developed.

In the two areas of infestation in New York, one complete generation each year was produced in 1919 and 1920, while in 1921 one complete generation and a limited partial second generation developed.

In the recently discovered areas infested by the European corn borer in Pennsylvania, Ohio, and Michigan there developed during the season of 1921 one complete and a limited partial second generation.

FIG. 16.—Chrysanthemum stem tunneled by European corn borer. (One-half natural size.)

NEW ENGLAND AREA.

The European corn borer passes the winter as a full-grown larva or borer within the tunnel made in its host or shelter plant during the previous summer and fall. The presence of such borers may be detected readily by small holes on the surface of infested plants, with masses of the frass, or castings of the borers, extruding therefrom. This frass is usually white or light brown and closely resembles sawdust. Upon cutting open these plants, the borers (Fig. 19) will be found within.

At this time the borer is nearly an inch long and one-eighth of an inch thick. The head is dark brown or black. The upper surface

of the body varies from light brown or dark brown to pink. Each segment, or division of the body, bears a row of small dark-brown spots, while several narrow dark-brown or pink lines extend lengthwise of the body. The under side of the body is flesh colored and devoid of markings.

As soon as warm weather begins, in April or May, the borers resume their activities, although little or no feeding takes place at this period.

About the middle of May the borer cuts a small circular opening from its tunnel to the surface of the plant in order to provide an

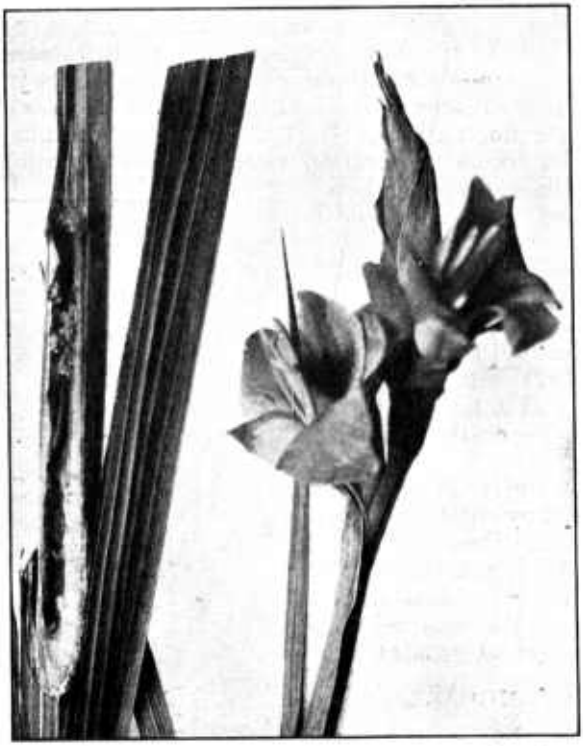

FIG. 17.—Gladiolus stems showing European corn borer infestation.

exit for the future moth. It then closes this hole with a thin partition of silk and retreats into its tunnel to a point near the last feeding or shelter place, where it spins a thin cocoon. Inside this cocoon the borer changes into the pupa or resting stage (Fig. 5, *c*, *d*; Fig. 20).

The pupa is shuttle shaped, light brown or dark brown, and from one-half to five-eighths of an inch in length. After remaining in this condition for about 19 days, or until the first week of June, the skin of the pupa splits and the fully developed adult or moth emerges.

The female moth (Fig. 21) has a robust body and a wing expanse of a little more than an inch. The general color is quite variable, and represents all shades from pale yellow to light brown. The outer thirds of both the forewing and hindwing are usually

crossed by two narrow zigzag lines darker than the rest of the wing. The male moth (Fig. 21) has a long, slender body, is slightly smaller in wing expanse, and is usually much darker than the female. The general color varies from pale brown to dark brown, sometimes with a blue tinge. The outer third of the wing is usually crossed by two narrow zigzag streaks of pale yellow, and there are frequently small pale-yellow areas on the forewings.

The moths are possessed of fairly strong powers of flight. Marked moths of both sexes have been recovered at distances of from 5 to

FIG. 18.—Oats showing European corn borer larvæ infesting stem.

nearly 20 miles from the point of liberation, while individual moths have been observed to make single flights of nearly 400 yards. During windy periods the direction of flight is usually with the wind.

Soon after emergence the moths mate and begin to deposit eggs. They remain quiet during the day, hiding in patches of weeds and grass or underneath the leaves of other plants. During the early evening and early morning they fly from plant to plant, depositing their eggs in flat, irregularly shaped masses (Fig. 5, *a*) usually composed of from 15 to 20 eggs. From 1 to 133 eggs have been found in individual masses. These egg masses are deposited principally

on the underside, although infrequently on the upper side, of a leaf, or on the stem of the host plant. Each egg overlaps the adjoining eggs in the manner of shingles. The female moths of this brood deposit an average of about 350 eggs each, but individual females under observation deposited as many as 724 to 1,192 eggs each. The average length of life of the moths of both sexes is about 18 days.

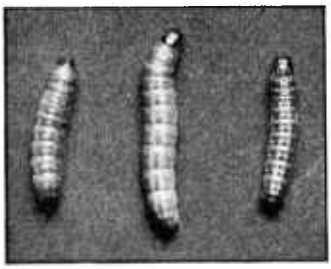

FIG. 19.—Larvæ of the European corn borer, slightly enlarged.

The egg is nearly flat and about one twenty-fifth of an inch in diameter. It is white when first deposited, but later changes to pale yellow, becoming darker just before the young larva or borer hatches therefrom.

The eggs hatch in from 4 to 12 days, with an average of about 7 days, the length of the egg stage varying with the climatic conditions. The newly hatched borer is about one-sixteenth of an inch long, with a black head and a pale yellow body, bearing several rows of small black or brown spots. It feeds for a few days upon the surface of the leaf, near its place of hatching, but soon enters the plant and completes most of its development therein. It may also migrate to other plants by crawling or spinning a suspending thread.

During its growth the borer molts, or changes its skin, five or six times, gradually becoming darker and increasing in size until it is of the same appearance and size as the overwintering borer previously described. By the third week of July, or about 38 days after hatching from the egg, the borer becomes full grown and changes to the pupa, or resting stage, usually inside its tunnel in the host plant. About 11 days later, during the last part of July, or in early August, the moths emerge from these pupæ and deposit their eggs as described for the first brood of moths in June. Many of these eggs are deposited directly upon or closely adjacent to the partly developed ears of field corn and of late sweet corn. An average of about 450 eggs are deposited by each female moth of this second brood, but individual females under observation deposited as many as 1,934 eggs each.

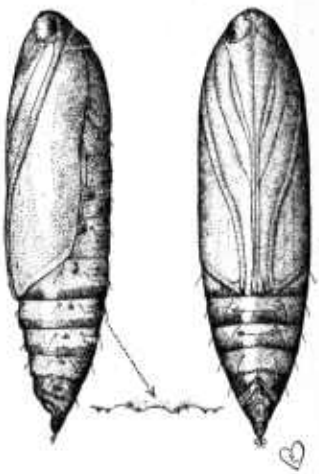

FIG. 20.—Pupa of the European corn borer, lateral and ventral views. About three times natural size. (Caffrey.)

The eggs of this generation hatch in about 7 days, and the resulting borers attack the plant in a manner similar to that described for the first generation.

At this time the injury to the ears of field corn and late sweet corn may be very great, due to the fact that many of the borers make their way directly into the ears after hatching from the egg, and feed within the partly developed ear.

The borers continue to feed at intervals until cold weather stops their activities, in November or early December. They remain in a hibernating condition within their tunnels in cornstalks, corncobs, weeds, crop remnants, or other hosts, throughout the winter.

As stated, there usually are two generations annually in the infested area of New England, and the female moths of both generations deposit an average of about 337 eggs each. As about half of the resulting moths are females, it is evident that the pest is able to multiply very rapidly.

The habits of some individuals of the European corn borer vary from the normal, and this fact should be taken into account when measures for the control or suppression of the insect are under consideration.

Some of the larger borers frequently leave infested plants, or plant material, when such plants are disturbed, or when the infested plants begin to wither or decay. This is especially likely to occur: (1) when infested cornstalks are being collected in the field; (2) when infested cornstalks are left in piles or "stacks" in the field, in the barnyard,

FIG. 21.—Adults, or moths, of the European corn borer: At left, female moth; at right, male moth. Not quite twice natural size.

or under shelter, with the consequent decay or drying out of the plants; (3) when badly infested plants collapse and break over in the field; (4) when infested plants with comparatively small stems, such as oats and some of the weeds, are cut while in a green condition with the consequent rapid withering or shriveling of the stems; (5) during the handling and shipment to market of infested plant products such as sweet-corn ears or beets with top; and (6) when certain plant products, such as celery, are placed in underground pits.

Under these circumstances the migrating borers have frequently been found boring into the crevices and walls of buildings, fences, posts, and other wooden objects. They also crawl underneath the loose bark of trees or fence posts and under rubbish, loose stones, old leaves, and clods of soil. Here they enclose themselves with a rough silken web. They have also been found in the corners and crevices of boxes used for shipping infested sweet-corn ears and similar products. Most of these borers are full grown and many of them are able to pupate and emerge as moths from these shelters.

Full-grown borers have been found to pass the winter successfully and to develop into moths when placed in empty boxes and boxes containing soil, sawdust, dry manure, old leaves, or moss.

The larger borers are able to live for at least a month without food, even during their active period of growth. This habit is especially important, as it renders the insects easily carried in infested material

which may be transported considerable distances or kept in storage for a long period.

Experiments have shown that many of the full-grown borers are able to survive total or partial submergence in either fresh or salt water for a period of at least 40 days during their inactive period in the late autumn, winter, or early spring. This fact has an important bearing on the possible drift of infested material in rivers, lakes, etc.

NEW YORK STATE AREAS.

The seasonal occurrence of each stage of the European corn borer is two or three weeks later in New York than in New England and the larva, or borer, stage is much longer.

According to records secured during 1920, the overwintering borers in New York began to enter the pupa or resting stage about the first week of June. The moths began to emerge about the last week of June and were present in the fields depositing eggs until the middle of August. Small borers were found attacking the plants during the first week of July. By the third week of August many of the early hatching borers were apparently nearly full grown, but instead of pupating and emerging as moths to deposit eggs for a second generation, as happens in New England, these large borers continued feeding or boring, with intervals of inactivity, until the advent of cold weather. The later-hatching borers became full grown during September and October.

In 1921 the seasonal occurrence of each stage of the insect in New York was about two or three weeks earlier than in 1920. As a result of this early development a limited second generation was produced. A few pupæ and moths of this second brood were found during late July and early August. These moths began depositing eggs of the second generation during the first week of August. The second-generation borers which hatched from these eggs reached full growth before the end of the season. The appearance of a second generation in this region, it is believed, will occur very rarely.

The general feeding habits of the European corn borer in New York are the same as in New England, except that in New England the borer is known to attack a greater variety of plants at the present time. This difference in feeding habits may be due to the lighter infestation at present existing in New York.

NATURAL ENEMIES.

Although quite a variety of natural enemies of the European corn borer have been recorded in this country, they do not usually attack the insect in any appreciable numbers, and can not be relied upon at the present time to hold the pest in check.

INSECT PARASITES.

In New England, a very small, four-winged, wasplike parasite[24] sometimes destroys large numbers of the eggs of the European

[24] *Trichogramma minutum* Riley.

corn borer. The adult or parent of this parasite deposits small eggs within the eggs of the European corn borer. These parasite eggs hatch into small maggots which devour the contents of the corn-borer eggs. During the late summer of 1919 an average of about 43 per cent and a maximum of 75 per cent of the second-generation eggs were parasitized, as shown by egg collections in 23 towns. In 1921 this parasite destroyed an average of about 30 per cent and a maximum of 74 per cent of the corn-borer eggs in 24 representative towns. This beneficial insect is very variable in its occurrence from year to year, as in 1920 only about 6 per cent of the second-generation eggs were destroyed in the same area. Less than 1 per cent of the first-generation eggs were parasitized each year during the period from 1919 to 1921.

A very small percentage of the borers are destroyed by the young or maggots of six different kinds of two-winged parasitic flies.[25] The maggots of these flies feed upon the internal juices and vital organs of the living borer and finally cause its death. Less than 1 per cent of the borers have been destroyed each year by these beneficial flies.

Eighteen different kinds of four-winged, wasplike parasites[26] have been reared from the larvæ and pupæ of the borer in New England. Less than 1 per cent of the borers have been destroyed each year by these parasites.

Some of the parasites which prey upon the borer in Europe have been introduced into the infested area of New England from France and Italy. The process of establishing these parasites is slow, however, and several years will probably elapse before the result of these introductions will be known.

BIRDS.

A few birds, including blackbirds, woodpeckers, robins, starlings, and pheasants, have been known to feed to a slight extent on the larvæ of the European corn borer in New England.[27] From present indications birds can not be expected to cause much reduction in the numbers of the pest.

INSECTS FREQUENTLY MISTAKEN FOR THE EUROPEAN CORN BORER.

Several different kinds of common and native caterpillars are frequently mistaken for the European corn borer. Some of these caterpillars are similar in appearance to the corn borer, while others are quite different in appearance, but the character of their work somewhat resembles that of the European corn borer. It is, there-

[25] *Phorocero erecta* Coq, *Exorista pyste* Walk., *Masicera myoidea* Desv., *Exorista nigripalpis* Towns., *Carcelia ochracea* V. D. W., and *Compsilura concinnata* Melg.

[26] *Itoplectis conquisitor* Say, *Sagaritis dubitatus* Cress., *Agrypon* sp., *Amblyteles brevicinctor* Say, *Amblyteles rubicundus* Cress., *Cryptus incertus* Cress., *Microbracon* sp., *Microgoster zonaria* Say, *Meteorus loxostegei* Vier., *Habrobracon gelechiae* Ashm., *Epiurus pterophori* Ashm., *Epiurus tecumseh* Vier., *Epiurus indagotor* Cress., *Bassus agilis* Cress., *Labrorychus prismaticus* Nort., *Ephialtes aequalis* Prov., *Campoplex* sp., and *Microbracon caulicola* Gahan.

[27] During 1920 the Bureau of Biological Survey investigated the relation of birds to the European corn borer in New England. As a result of this investigation, one borer was found in the stomach of a pheasant and six borers in the stomach of a single starling. No other species of birds were found to be feeding on the pest at that time.

fore, recommended that any questionable insects found boring in corn be sent to the nearest agricultural experiment station, or to the Bureau of Entomology, for identification.

THE CORN EARWORM.[28]

On account of the similarity of its damage to the ears of corn, the corn earworm (Fig. 22) is very often mistaken for the corn borer. This insect is also known as the cotton bollworm, tomato fruitworm, and tobacco budworm.

The corn earworm, however, is not a true boring insect and usually confines its damage to the silk and kernels of the ear, whereas the corn borer habitually feeds not only upon the silk and kernels of the ear, but also bores into the cob. Unlike the corn borer, the corn earworm does not bore into the stalks, although if the ears have not developed on young plants it often feeds upon the leaves and in the growing tip or "bud" of the plant. This injury sometimes results in broken-over tassels which at a distance resemble corn-borer damage, but close examination will show that these tassel stems have not been tunneled. This characteristic serves to distinguish such injury from that of the corn borer. During the late fall, winter, and early spring the corn earworm is never present in the ears of corn or in the stalks, whereas the corn borer may commonly be found in ears and stalks of corn at this time in areas where the insect is numerous.

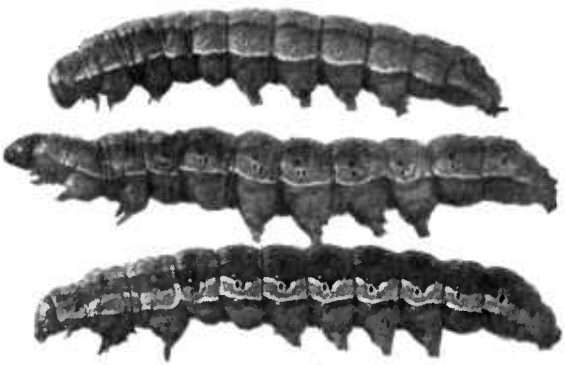

FIG. 22.—Three corn earworm larvæ, seen from the side, showing color types: Upper larva, green; middle one, rose colored; lower one, dark brown. Not quite twice natural size. (Quaintance and Brues.)

The caterpillars of the corn earworm are about 1½ inches long when full grown and very variable in color, ranging from tints of green, pink, rose, yellow, and brown to almost black. They may be beautifully striped, or spotted, with brown, black, or yellow along the side and back, or they may be entirely free of stripes or spots. In appearance they can be readily distinguished from the corn borer by the fact that they are nearly twice the size of the latter. The hairs arising from the *black* tubercles, or warts, on the back of the earworm are much longer and stouter than those arising from the *brown* tubercles on the back of the corn borer. The castings of the earworm are coarse, wet, and foul, while those of the corn borer are more finely divided and usually dry. This insect is widely distributed throughout the corn region of the country and did infinitely more damage in 1921 than the corn borer.

[28] *Heliothis obsoleta* Fab.

THE STALK-BORER.[29]

The stalk-borer (Fig. 23) is often very numerous during the early summer in some sections of the country. It works habitually within the growing tip (heart) and stalk of young corn, and is frequently mistaken for the European corn borer on account of its habit of boring in the cornstalks. In addition to corn, it also bores in the stalks, and infrequently in the fruit, of several other cultivated crops and flowers, and in weeds.

The young caterpillars of the stalk-borer are very easy to distinguish from the corn borer, as they bear a dark-brown or purple band around the middle of the body, and several conspicuous brown or

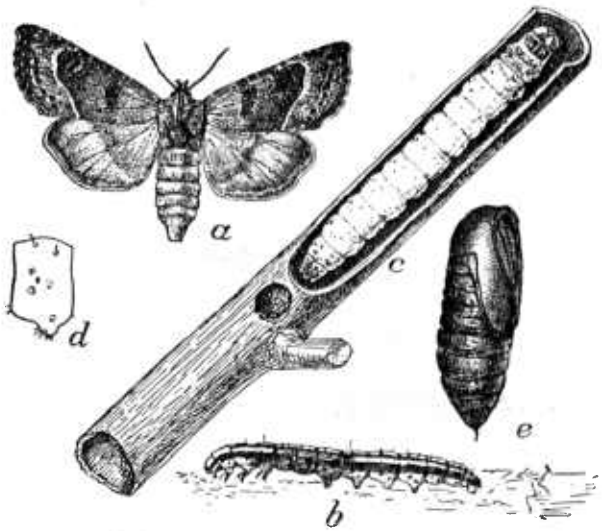

FIG. 23.—Stalk-borer: *a*, Female moth; *b*, half-grown larva, or borer; *c*, full-grown larva in injured stalk; *d*, side view of segment of abdomen of same; *e*, pupa. All somewhat enlarged. (Chittenden.)

purple stripes run lengthwise of the body. The corn borer does not possess these conspicuous bands or stripes. As the stalk-borer becomes full grown, however, these bands and stripes disappear and the color becomes plain creamy white or light purple, with only inconspicuous markings. The full-grown stalk-borer is slightly over an inch long and is much larger throughout than the corn borer. It is never found in cornstalks during the winter.

THE SMARTWEED BORER.[30]

The smartweed borer is very frequently found in corn during the autumn, winter, and spring. The appearance and work of this native borer resemble that of the European corn borer so closely that it is very difficult to distinguish between them. The smartweed borer usually feeds within the stems of smartweed,[31] but it commonly bores into the stalks of corn and other plants when seeking winter quarters.

[29] *Papaipema nitela* Guen.
[30] *Pyrausta ainsliei* Heinrich.
[31] *Polygonum* spp.

It is known to be very numerous throughout the eastern part of the country, and many reports of European corn borer occurrence have been due to the presence of the smartweed borer.

The caterpillars of the smartweed borer are about three-fourths of an inch long when full grown, slightly smaller than the corn borer, and less robust. They are always slate-colored or gray when full grown, and in the living state they bear a very fine, faint line of darker color running along the middle of the back, whereas in the corn borer this line is decidedly broader and very conspicuous in the living borer. Except for these differences, and one or two microscopic distinctions which are discernible only to an entomologist, these two kinds of borers have the same appearance when full grown. On hatching from the eggs the small caterpillars of the corn borer have black heads, while those of the smartweed borer have pale amber-colored heads.

THE CELERY STALKWORM.[32]

In Massachusetts the celery stalkworm has been frequently found working in celery stalks along with the European corn borer, and on account of its similarity in appearance and damage it has often been confused with the latter. The celery stalkworm, however, usually confines its injury to the surface of the celery stalks, while the corn borer enters the stalks and feeds within as well as upon the surface of the stalks.

The caterpillar of the celery stalkworm is about thirteen-sixteenths of an inch long when full grown, and it resembles the corn borer in general color. The tubercles, or warts, on its back are larger, darker, and support much longer hairs than those of the corn borer. The celery stalkworm is much more active than the corn borer, and moves backward or forward with equal rapidity. It is not known to attack corn.

THE LINED STALK-BORER.[33]

The lined stalk-borer has frequently been confused with the European corn borer in Ohio and to a lesser extent in New York. The work of the lined stalk-borer greatly resembles that which has been described for the stalk-borer, and is usually confined to young corn, especially corn which has been planted on sod land.

The caterpillars of the lined stalk-borer are nearly an inch long and yellowish-white, with several conspicuous reddish-brown stripes running lengthwise of the body. They may be easily distinguished from the corn borer by the presence of these conspicuous stripes and by the absence of the small brown tubercles or "warts" which are present on the corn borer.

THE LARGER CORN STALK-BORER.[34]

In the Southern States, and especially in the South Atlantic States, the larger corn stalk-borer (Fig. 24) is a common enemy of the corn plant, and owing to its habit of tunneling in the stalks of corn it may

[32] *Nomophila noctuella* Denis and Schiff.
[33] *Hadena fractilinea* Grote.
[34] *Diatraea zeacolella* Dyar.

be easily confused with the European corn borer. The larger corn stalk-borer, however, does not bore into the ears of corn, whereas this habit is characteristie of the eorn borer. This southern pest habitually overwinters only in the rootstock of the corn, whereas the corn borer not only winters in the stubble of corn, but may also be found in the stalks and ears of corn and in the stubble and stems of many other plants previously mentioned as hosts.

The caterpillars of the larger corn stalk-borer are of two types—a summer form and a winter form. The summer form, when full

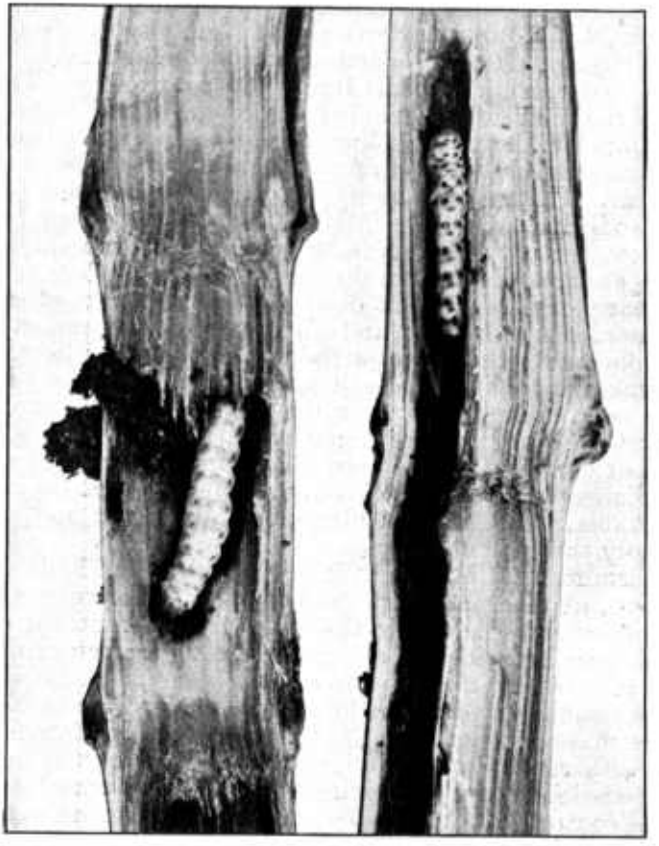

FIG. 24.—The larger corn stalk-borer. Natural size.

grown, is about 1 inch in length, with a dirty white body thickly dotted with round or irregularly shaped darkly colored spots. Each of these spots bears a short, dark bristle. The head region is brownish yellow. The winter form differs from the summer form in that the caterpillar is more robust and is slightly shorter, while the spots referred to above are nearly the same color as the body. In the Gulf strip and on the Mexican border two distinct but very similar and closely related caterpillars[35] may attack corn.

[35] *Diatraea saccharalis* Fab. and *Diatraea lineolata* Walker.

PREVENTING THE SPREAD OF THE INSECT.

THE FEDERAL QUARANTINE AGAINST THE CORN BORER.

The importation from foreign territory of plants likely to contain the European corn borer is regulated or forbidden by the terms of the Federal Quarantine, No. 41, effective July 21, 1921. This is enforced by inspectors of the Federal Horticultural Board at all ports of entry throughout the country.

A domestic Federal Quarantine, No. 43, against the European corn borer was declared by the Secretary of Agriculture, effective on and after March 29, 1920. It is administered by the Federal Horticultural Board in cooperation with the Bureau of Entomology. The original items of the quarantine included 111 towns in Massachusetts, 3 in New Hampshire, 40 in New York, and 1 township in Pennsylvania, and prohibited the shipment of the quarantined products during the entire year. This quarantine was subsequently amended (September 2, 1922) to include 161 towns in Massachusetts, 12 in New Hampshire, 150 in New York, 6 townships in Michigan, 57 in Ohio, and 17 in Pennsylvania, and provides that in the case of corn and broom corn, including all parts of the stalk, cut flowers or entire plants of chrysanthemum, aster, cosmos, zinnia, hollyhock, and cut flowers, entire plants of gladiolus and dahlia, except the bulbs thereof without stems, the quarantine and regulations shall apply throughout the year, and in the case of all other products for the period between June 1 and December 31, in New England territory. It further provides that in the case of corn and broom corn (including all parts of the stalk), all sorghums, and Sudan grass, from infested areas in New York, Pennsylvania, Ohio, and Michigan, the quarantine and regulations shall apply throughout the year.

An amendment of May 1, 1922, provides that the limitation of the restrictions of this quarantine, as provided in the rules and regulations supplemental hereto, to the areas in a quarantined State now, or which may hereafter be, designated by the Secretary of Agriculture as infested by the European corn borer, shall be conditioned upon the establishment and enforcement by the State of such control measures in cooperation with the United States Department of Agriculture with respect to the designated infested areas as in the judgment of the Secretary of Agriculture shall be deemed adequate to effect the control and prevent the spread of the European corn borer.

The inspection and certification of all products, cut flowers, etc. (except spinach), under quarantine, grown within the quarantined area, is conducted in the wholesale markets in all cases, except when the grower ships directly to points outside of the quarantined area, when inspection is made on the premises.

Where the products are found free from infestation by the European corn borer, certificates are granted to cover shipment, each package being covered by a separate certificate. Such certificates (always excepting corn, which can not be certified) permit the product to move outside of the quarantined area. Inspection of spinach is made only in the field.

The terms of this quarantine are enforced in the wholesale vegetable and flower markets by inspectors employed by the Bureau of Entom-

ology. An inspector's office is maintained in the center of the wholesale vegetable districts and in the flower markets in the infested areas. Telephone service is provided and inspectors are on duty at these places from 7 a. m. to 6 p. m., and are subject to the call of merchants, forwarding agents, and private individuals who may wish to ship quarantined products to points outside of the infested areas. Such inspectors are provided with badges of authority issued by the Bureau of Entomology and the Federal Horticultural Board, and supplied with the necessary permits authorizing shipments.

The method pursued may be briefly outlined as follows: A commission merchant receives an order for products included in the quarantine, to be shipped to a point outside the infested area. The products which he wishes to ship were received from some point outside the infested area, but having been received into the infested area, must be covered by a permit authorizing the railroads and express companies to accept them. The person interested notifies the inspector's office by telephone, and the inspector immediately proceeds to the place where the products are located, satisfies himself of their origin by inspecting waybill or other documentary evidence presented, and issues the necessary permits. Where products are grown within the quarantined area, they must be inspected before permits will be granted. These permits are printed on a durable grade of paper, and bear the facsimile signature of the officer in charge of European Corn Borer Control. They are securely fastened to the package in the presence of the inspector. A force of men, sufficient to meet the demand, is maintained in the wholesale flower and vegetable markets within the infested area.

In order to facilitate the shipment of goods packed in oat or rye straw, permits are issued to large commercial houses using hay or straw originating outside the quarantined area, upon satisfactory evidence of origin. In the case of individuals or small concerns who make an occasional shipment, it is necessary for inspectors to issue permits as required.

A constant watch is maintained at railroad, steamship, and electric terminals to prevent violations of the quarantine. A similar surveillance is maintained over long-distance trucks departing from the wholesale market districts for points outside the quarantined area.

Inspectors are also stationed on all main traveled roads at State lines within infested areas during the growing season, for the purpose of stopping and inspecting vehicles to ascertain whether they are carrying products included in Quarantine No. 43. "Warning" posters (see cover-page illustration) are displayed at all roadside stands, produce markets, railroad stations, steamship wharves, express offices, and other public places throughout the infested area, to caution the public against attempting to transport quarantined products to points outside of the infested area. Copies of Quarantine No. 43 may be obtained free of charge upon application to the Secretary of Agriculture or the Federal Horticultural Board, Washington, D. C.

PENALTY FOR VIOLATION OF PLANT QUARANTINE ACT.

The plant quarantine act, August 20, 1912, as amended March 4, 1913, and March 4, 1917, provides: "That any person who shall violate any of the provisions of this act, or who shall forge, counterfeit, alter, deface, or destroy any certificate provided for in this act or in the regulations of the Secretary of Agriculture, shall be deemed guilty of a misdemeanor and shall, upon conviction thereof, be punished by a fine not exceeding $500 or by imprisonment not exceeding one year, or both such fine and imprisonment, in the discretion of the court."

ARTIFICIAL CARRIERS OTHER THAN QUARANTINED PLANTS.

GARBAGE.

During the summer and early autumn the kitchen garbage from hotels, restaurants, private homes, and the like, may contain living borers, or pupæ, in ears or cobs of sweet corn, or portions thereof, which have been discarded after purchase, on account of the presence of the insect. Borers are also frequently present in the husks, silk, undeveloped tips, and the "shank" of the ears. These portions are commonly removed from sweet-corn ears before cooking and thrown into the swill container. Other plant material which frequently harbors the insect and which is commonly discarded during preparation for the table includes the outer stalks of celery, and injured portions of beet tops, rhubarb, Swiss chard, spinach, and string beans.

Garbage of this character may act as a carrier of the insect to new localities, as it is frequently transported considerable distances for use as food for pigs or disposal otherwise. Under these conditions the borers may escape en route, or before the swill is disposed of. Garbage is sometimes thrown into streams or bodies of water which may carry such material long distances through the influence of currents, wind, or tide. Corncobs which have been thrown into pigpens, and subsequently removed when cleaning out the pens, have been found to contain living borers.

Collections of garbage made during the summer, autumn, and spring very frequently contain quantities of infested material consisting of cornstalks, other crop remnants, flowering plants, weeds, and similar plant material. Infested cornstalks and other plant material containing living borers have been found distributed along the beaches of New England, and also upon the shores of islands several miles from the mainland. Infested material of this kind has also been found distributed along the shore of Lake Erie on the Canadian side. It is probable that some of this material, especially cornstalks and weeds, may be washed into streams, and eventually into the ocean or lakes, from farms and gardens during heavy rains or floods.

The dispersion of the borer by means of infested garbage, crop remnants, and certain waste products, as discussed above, is believed to be at least a contributing cause of some of the infestations along the coast of New England and the shore of Lake Erie, as well as along some of the river valleys within the infested areas.

WASTE PRODUCTS.

REFUSE FROM BROOM FACTORIES.

Broom corn when received at broom factories, in the raw state, usually consists of from 18 to 36 inches of the upper part of the broom-corn plant, including the "hurls" or that portion used in brooms, and the upper part of the stalk or "butt."

The European corn borer has been found commonly in that portion of the plant comprising the "butt" in broom corn grown in Massachusetts and also in the "butts" of imported broom-corn material received from Italy. During the process of manufacturing brooms, sections several inches long are usually removed from the base of these "butts" and discarded as refuse. This refuse may become a source of danger, especially when dumped along the banks of water courses. The original infestation along the Mohawk River in eastern New York is supposed to be directly traceable to infested refuse from a broom factory at Amsterdam.

REFUSE FROM CANNING FACTORIES.

The refuse from canning factories using sweet corn from infested areas commonly contains large numbers of living borers. This refuse usually consists of the cobs, husks, silk, "shanks," and ears on which the kernels are not properly developed or are affected by insects or plant diseases. Most of this infested material is hauled away by farmers, often to points outside the infested area, and fed to live stock or used as fertilizer. Under these conditions some of the borers may escape en route and others may escape after reaching the farm, thus starting new infestations.

CONTROL OF EUROPEAN CORN BORER.

INEFFECTIVE MEASURES.

Arsenical poisons not efficient.—The application of arsenical poisons has not been found to protect growing corn plants from injury by the European corn borer, although numbers of the borers may be poisoned in this manner during their early stages. During that period they feed to a slight extent upon the surface of the plants, especially on the leaf blades, but the eggs are deposited over a long period of time, during the growing season, and the borers are hatching almost daily, so that very frequent treatments are necessary in order to keep rapidly growing corn plants covered with the arsenical. Even where as many as 12 arsenical applications were made carefully and at the most advantageous periods, it was found that the plants were severely injured by the borers which escaped the treatments. The substances used in this work were lead arsenate, calcium arsenate, magnesium arsenate, and sodium arsenite in the liquid form at various strengths, and also in combination with nicotine sulphate. Some of these substances were also applied in the powdered form and in combination with hydrated lime.

The cost of applying several treatments of these poisons is prohibitive under field conditions, and they are not recommended to prevent injury by the European corn borer.

METHODS OF CONTROL EFFECTIVE UNDER RESTRICTED CONDITIONS.

REGULATING TIME OF PLANTING.

Injury to the early maturing crops of sweet corn may be reduced to an uncertain extent by regulating the time of planting. On many of the farms and market gardens, where a series of sweet-corn plantings are made on different dates, there is usually a very noticeable difference in the amount of injury to each planting, even where these consist of the same variety, in adjoining areas and under the same soil conditions.

The first planting of early sweet corn is usually injured by the borer to a much greater degree than plantings made from 10 days to 3 weeks later. In Massachusetts sweet corn planted from about April 15 to May 10 has been injured to a greater extent than sweet corn planted from about May 20 to May 30. In New York the earliest planted sweet corn (about May 10) is usually infested to a greater degree than that planted about 10 or 20 days later. The dates of these plantings necessarily will vary from year to year, according to weather conditions, and also with the local development of the season. This method can not be applied for limiting the amount of injury to field corn or late crops of sweet corn in New England, according to present information. These crops are at an attractive stage during the late summer, when the insect is most active and when many of the moths of the second generation in New England are depositing their eggs directly upon the ears.

The variation in the amount of injury to early sweet corn planted at different times may be explained by the fact that at this time of year the moths apparently prefer to deposit their eggs on well-developed plants which have not reached the matured-tassel stage. Subsequently, when later-planted corn becomes available, most of the moths have deposited their eggs, and these later plantings escape serious injury. Although egg masses are frequently found on the leaf blades of very small corn plants, the young borers commonly leave such corn soon after hatching, and enter weeds or other plants near by which have reached a more advanced stage of development.

TRAP CROPS.

Attention has been called to the fact that the earliest plantings of sweet corn usually attract many of the moths which have developed from the overwintering borers, and that these early plantings are commonly very heavily infested. This immediately suggests the use of very early planted sweet corn in fields intended for a main crop of field corn or late sweet corn to act as a trap crop; such plantings to be carefully destroyed, with the contained borers, as soon as the ears are harvested, or preferably just before that period, where the grower is willing to sacrifice the ears and use the plants as green feed for live stock.

This method of limiting damage to the main crop of field corn or late sweet corn might be particularly useful in the one-generation areas of New York. In the two-generation area of New England it can only be used to advantage on the larger fields or farms, judging from results secured at the present writing. On the small farms

and market gardens, which now predominate in the badly infested portion of New England, any benefits to field corn or late sweet corn which may be derived from the destruction of a trap crop appear to be partly nullified by the flight of the second-brood moths from adjoining areas of weeds or early corn which has not been destroyed.

Caution.—*Trap-crop plantings which are not destroyed at the proper time constitute a menace to later corn or other susceptible crops.*

SELECTION OF VARIETIES.

Field observations and experimental tests have indicated in some instances that certain varieties of field corn and of sweet corn are less susceptible to severe injury by the corn borer than others.

This apparent difference is usually involved to a certain extent with the time of planting and also with the rapidity or size of growth and the consequent period of maturity. It does not appear, therefore, that any variety on which observations have been made to date possesses anything like entire immunity from attack by the borer, although some varieties suffer much less injury than others.

The varieties of corn having large, heavy stalks seem able to withstand injury to a much greater extent than the slender varieties. This seems especially true of the large, robust dent varieties, such as are grown widely in the Corn Belt States. Throughout the present areas of infestation the northern-grown, early maturing varieties of flint field corn predominate and are usually injured to a greater degree than the later maturing varieties of dent field corn. The stalks and grain of the early maturing varieties of dent field corn appear to be quite susceptible to infestation. Compared with the flint or early dent varieties, the relatively smaller amount of injury observed in the late varieties of dent corn, at least in New York and New England, may be due to their slower development and later maturity, and also to the fact that their greater bulk is able to withstand the work of the borers without so seriously affecting the development of the stalk or ear.

PLOWING UNDER.

The effectiveness of plowing down infested corn stubble, weeds, and crop remnants as a farm practice in reducing corn-borer damage has been made the subject of extensive investigation. It has been determined that by **thoroughly** plowing under this infested material **during the fall**, especially in the soils of eastern Massachusetts, a large proportion of the borers contained in such material are destroyed. This measure alone will probably prove ineffective. In order that it may be rendered even partly effective, practically **all** of the infested material in infested fields must be plowed down to a depth of at least 6 inches in soils of ordinary texture. Deeper plowing increases the effectiveness of this operation and should be adopted when practicable, whenever the character of the soil will permit. Breaking down the cornstalks, stubble, or other standing plant material with a heavy roller, or by dragging with a heavy pole or iron rod before plowing them under, greatly increases the effectiveness of the work. Disk harrowing immediately after plowing serves to break up large clods of soil and aids in burying the plant material where the soil is in a condition that will allow this treatment.

The practice of plowing down infested material in the fall must be regarded as only an aid, or "finishing touch," to other repressive or clean-up measures. In ordinary farm plowing operations, considerable quantities of plant remnants are left on the surface of the soil, or are only partially buried. It is possible, however, under favorable conditions, by exercising proper care, to cover the infested material sufficiently to cause the destruction of many of the contained borers. Any loose plant material left on the surface of the soil should be raked into piles and burned.

Spring plowing has not proved effective, apparently because the borers become active before the soil is in condition for plowing in the spring, and if plowed under at this time, many of them make their way to the surface, even when buried under several inches of soil.

When necessary to plow down fields of standing cornstalks, it is advisable to run a stalk cutter over the field before plowing in order to roll down the stalks and cut them into sections.

PROTECTING GREENHOUSE PLANTS.

Good results have been secured in protecting chrysanthemums and other susceptible plants grown in greenhouses by screening all doors, ventilators, and other openings in such a manner as to prevent the moths from entering the greenhouse. These screens should be put on during the early spring (about May 15), and left in position until the late fall (about November 15). Screen cloth, cheesecloth, and similar materials are suitable for this purpose.

This method is not effective where the plants are allowed to become partly grown in infested fields during the summer and are subsequently moved into the greenhouse in the fall to complete their growth.

Cornstalks, corncobs, large weed stems, and similar plant remnants which are likely to contain the borer should be removed from manure or compost which is intended for use in the greenhouse.

METHODS RECOMMENDED IN MARKET GARDENS.

ABANDONMENT OF SUSCEPTIBLE CROPS.

Several crops commonly grown on market-garden farms in eastern Massachusetts are favorite host plants of the European corn borer, and furnish food for large numbers of caterpillars of the first generation. The resulting moths deposit eggs on later crops and thus produce a second generation of borers in such crops. Sweet corn, which is very susceptible to infestation by the borer within the very heavily infested area in Massachusetts, might profitably be abandoned on market-garden farms, except as a trap crop to be disposed of before July 25. Rhubarb is also attractive to the corn borer, so that it would be advisable to abandon the growing of this crop in badly infested fields, especially where other less susceptible crops may be grown with equal profit. Beet plants are a favorite host for the corn borer, but where these are grown in the early season and sold as bunch beets, or as greens, they are not in the field long enough

for the corn borers to mature. For this reason beets should be grown in heavily infested regions only as an early crop and should not be allowed to remain in the field after July 25.

No corn-borer infestation has been observed to date in rhubarb or beets grown under glass.

PLANT QUICK-GROWING CROPS AND CROPS WHICH ARE NOT SUSCEPTIBLE.

The crops grown on these market-garden farms can be handled in a manner to prevent their becoming host plants for the corn borer to develop in. Crops that mature quickly, such as early bunch beets, spinach, and green beans, do not furnish favorable conditions for the development of large numbers of corn borers. Celery, tomatoes, potatoes, and peppers are not likely to be injured by the corn borer where the fields are kept free from weeds, and where corn or rhubarb is not grown in their immediate vicinity.

Cabbage, carrots, cauliflower, cucumbers, dandelion, eggplant, lettuce, onions, parsnips, peas, radishes, squash, and turnips are some of the market-garden crops which may be grown in any situation with very little danger of infestation by the corn borer.

GENERAL METHODS OF SUPPRESSION AND CONTROL.

Any method of suppressing or controlling the European corn borer necessitates the destruction of infested material. This may be done to the best advantage by burning, placing in silo, feeding to live stock, burying in heated manure, or spraying weeds with chemical, weed-killing solutions.

BURNING INFESTED MATERIAL.

The burning of cornstalks and stubble may best be done in the spring or in late winter when the stalks are in a dry condition, and considerable care should be used in the preparation of fires. Some arrangement is necessary whereby a draft can be obtained. This can be done by raising the material to be burned a few inches from the ground by the use of stones or otherwise. In the damp climate of eastern New England the burning of cornstalks is often attended with some difficulty.

Where fields of corn stubble are located near wood lots, a few sticks of dry wood are always available and valuable in starting fires. The application of kerosene by means of ordinary watering pots helps considerably in burning such material. Special attention should be given to the entire consumption by fire of all cornstalks, cobs, and stubble. The process of shelling corn does not injure the borers contained in the cobs, and in infested regions all cobs should be burned immediately after shelling. Corn carried through the winter on the cob and not shelled before May 1 should be placed in a container, so that the moths can not escape after emerging. If a wire screen is used, one having at least 12 meshes to the inch will give satisfaction.

The burning of weeds and crop remnants is easier, as such material will burn readily if left to dry in the sun for a day or two. Any weed or crop-remnant material should not be allowed to dry

more than two days after cutting in summer before being burned. If it is allowed to remain longer the borers are likely to leave the infested stalks.

METHODS ADAPTED TO GENERAL FARMING.

Where farms are divided into wood lot, pasture, meadow, and small grains, and only a few acres are in corn, the European corn borer is comparatively easy to control, especially in districts where corn alone is infested.

To accomplish this, all cornstalks should be cut close to the ground as early as the purpose for which they are grown will permit. If this is done with a cutter and binder, the cutter knife should be set as low as possible. If done by hand, a short-handled garden hoe with sharpened blade may be used effectively, and with this tool the stalks and stubble can be cut almost even with the surface of the ground. A corn knife with a blade having a right-angle turn at the end is also convenient for this purpose.

In disposing of cornstalks, care should be taken to destroy them immediately after cutting, either by placing in the silo, shredding and feeding direct to live stock, plowing under, or burning. Good results can not be obtained if stalks are allowed to stand in the fields throughout the winter, because under some conditions many borers migrate to other places of hibernation from such stalks. These operations should be conducted as early in the fall as possible in order to be effective.

The practice of dragging fields of standing stalks with a heavy pole or iron rail while the ground is frozen, and subsequently gathering and burning the broken stalks, is strongly recommended as most useful in the control of the corn borer.

In the spring of the year (before May 1) a good general cleaning up of all corn remnants around barns, etc., should be conducted and such remnants burned.

In areas where the corn borer is seriously damaging fodder corn, it is recommended that alfalfa, red clover, vetch, barley, or similar forage crops be grown, as these crops are not likely to be infested by the corn borer.

BURYING DEEPLY IN SOIL.

Small quantities of infested material may be conveniently and effectively disposed of by burying deeply in the soil during the fall. When this method is followed, it is recommended that the material be covered by at least 18 inches of soil.

BURYING WITHIN PILES OF FRESH HORSE MANURE.

Burying or covering infested plant material in piles of heating horse manure leads to the quick destruction of any borers contained in material thus treated. Care should be taken that the material is completely covered with several inches of manure. This method may often be used to advantage on farms and market garden or florist establishments where large quantities of horse manure are available, but it is not recommended for use in manure or compost which is not in a heating condition.

When corn fodder is used for bedding, or for feeding, the uneaten parts should be kept out of the manure, and burned or otherwise

destroyed, unless it is possible to work these portions deeply into manure that is in a heating condition.

DESTRUCTION OF WEEDS.

Weeds serve as refuges for the corn borer and may be killed by spraying with certain chemicals in solution. Many chemicals have been used for this purpose but the two in most common use are iron sulphate and sodium arsenite. Young corn borer larvæ feeding in the tips of weeds may often be killed by such chemicals, but the number destroyed is not sufficient to render this method of value against the corn borer. However, such methods are valuable in destroying weeds on uncultivated land, as in meadows, lawns, borders of roadsides, on public dumping grounds, and on vacant city lots, thus preventing the weeds from becoming a possible source of infestation.

Any reliable type of sprayer may be used in applying these solutions. For large operations on rough land a power sprayer equipped with long lines of hose is most useful. In the experiments carried on by the Bureau of Entomology, a large power sprayer carrying a 400-gallon wooden tank, mounted on an auto truck, was used. A single line of ½-inch hose was run from each tank and fitted with a solid-stream nozzle carrying a $\frac{3}{32}$-inch tip. The method of operation was to run out the entire length of hose, and working back toward the pump, spray a strip about 50 feet wide, repeating this operation until the entire field was covered.

Care should be taken to protect the skin of the operator from the solutions containing sodium arsenite, as this produces severe burning. The remedy for such burns is to apply vinegar to the parts affected.

Weeds should be sprayed before they go to seed, but should not be sprayed when too young as their places may be taken by new plants that sprout from old seed, or new stems may arise from the roots. The best time to spray weeds is when they are in flower, or just before the flowers are formed.

Iron sulphate is often used for killing mustard in grain fields and dandelions in lawns. It will kill almost all broad-leaved weeds, but does not kill grass. There is no danger of poisoning animals which may graze on such sprayed plants. Iron sulphate is also useful for destroying meadow and roadside weeds.

Sodium arsenite is one of the best of the chemical weed killers and is the basis of many of the commercial weed-killing solutions on the market. **It is very poisonous to animals and precautions should be taken to prevent live stock from grazing where plants have been sprayed.** It may be used effectively on public dumping grounds, on vacant city lots, along railroad right-of-ways, or any place where there is no danger of animals grazing. This solution is used at the rate of 3 pounds of sodium arsenite to 100 gallons of water.

Either of the foregoing solutions may be used for destroying weeds on farms, but care should be taken to prevent animals from grazing on plants that have been sprayed with sodium arsenite. It should also be remembered that these solutions kill cultivated plants, and it is difficult to use them along fences and ditches, because the wind is likely to carry some of the solution to the crops. They are useful for destroying weed patches where the land is uneven or

where obstructions prevent mowing. The cost of this operation varies, according to the amount of solution used, from $11 per acre up.

In some cases it may become desirable to use a flame-throwing torch with oil as a fuel. In this event any reliable sprayer may be used to produce a spray for oil-burning purposes, providing it is capable of maintaining 100 pounds pressure and is fitted with a spray rod and Bordeaux nozzle. Caution must be exercised to have the nozzle opened as little as possible at 100 pounds pressure, so that oil may not remain on the ground unconsumed. It is advisable to procure ½-inch "oil hose" if possible, as the ordinary spray hose will not last long when used for oil.

Oil-burning of weed areas, headlands, and patches is sometimes useful, especially under suburban conditions, and can be done most economically during the spring, when the material to be burned is dry. At such times it is possible to destroy 99 per cent of the borers contained in the material so treated. It is possible to burn weeds in this way sufficiently when they are green so that, even where they are not entirely consumed by the fire, the heat produced is so intense that the borers are killed. The cost of burning weed areas is high and varies from $12 per acre upward, depending upon the fuel used and the condition of the weed growth. Clean, light fuel oil, not heavier than 0.36 to 0.40 specific gravity, is the cheapest for large operations. Ordinary kerosene is easier to secure and cleaner to handle. After the hose and sprayer have been used for this work, they should be thoroughly washed with soapsuds. Burning over weed areas, after the weeds have been mowed, is helpful, as many borers are likely to be left in the stubble. Oil burning is also of much assistance in consuming material that has been piled or cornstalks that have been raked into windrows.

In the Boston market-garden towns several species of weeds are often heavily infested with the European corn borer. In the cultivated fields these weeds are usually destroyed by cultivation or are plowed under, and many corn borers are killed by these methods. Weeds on the headlands, along fences and ditches, and around buildings are allowed to grow unmolested, however, and furnish ideal breeding places where large numbers of moths are produced to infest cultivated crops in neighboring fields. These fields should be plowed as close to the fences and ditches as possible, thus furnishing more land for cultivation and less for weeds. Orchards should be kept cultivated. Uncultivated land around buildings should be kept as lawns, and uncultivated fields should be turned into meadows or pasture.

Many of the common host plants of the corn borer which occur on the farm, such as barnyard grass, pigweed, smartweed, cocklebur, and horseweed, may be eradicated if they are kept from going to seed. For this reason it is advisable to mow the weeds along fences and around buildings before seed is produced. In order to destroy the corn borers, the weeds should be cut close to the ground, and should be raked into piles and burned as soon as possible. This can usually be done the day after they are cut. If the mowing is delayed until the weeds are in flower, most of such weeds will be killed. Any weeds which send up new stems, or which sprout from new seed, may be destroyed in the fall, winter, or spring by burning over such areas. As most of the headlands and land around buildings are covered

with grass, this grass will crowd out the weeds if the mowing and burning is continued for several years. Even the perennial weeds like tansy and goldenrod will be crowded out by the grass if they are mowed, or sprayed with weed-killing substances, several times during the season. Yellow dock, however, is best eradicated by grubbing in the spring. Quantities of weed seeds are often brought on to the land in manure, and for this reason all manure used on garden land should be well composted.

FEEDING INFESTED PLANTS TO LIVE STOCK.

Feeding infested fodder plants to live stock is one of the most effective and economical methods for combating the corn borer. The food value of the fodder is not materially affected by the presence of the borers, except possibly in cases of very severe infestation.

Wherever practicable, the infested plants should be cut close to the ground while green, and placed in the silo, or fed direct from the field. Any borers which escape the silage cutter are destroyed by the conditions existing in the ordinary silo. The common method of feeding corn fodder without shredding does not aid in the least to control the corn borer.

Mature plants, especially cornstalks when too dry to be used for silage, should be shredded, or cut into short sections, before being fed. Live stock relish corn fodder which has been shredded, and this promotes the consumption of the fodder.

When infested cornstalks, or similar plants, are fed direct to live stock, the uneaten parts should be collected and destroyed, preferably by burning.

DESTRUCTION OF CROP REMNANTS.

Celery tops, beet tops, fragments of cornstalks, rhubarb tops, tomato vines, and bean vines which are infested should be destroyed as soon as the crop is harvested, because the borer will crawl from these crop remnants to the growing crops if they are left in the field.

SUMMARY OF CONTROL AND RESTRICTIVE MEASURES.

To control the European corn borer the following practices are recommended:

Burn, or otherwise destroy, before May 1 of each year, all cornstalks, corncobs, corn stubble, vegetable, field, and flower crop remnants, weeds, and large-stemmed grasses of the previous year. Remove all remnants of leaves from rhubarb stems before marketing.

Keep cultivated fields, fence rows, field borders, roadsides, etc., free from large weeds or large-stemmed grasses.

Cut corn close to the ground.

Cut and remove sweet-corn fodder from the field as soon as the ears are harvested. Feed direct to live stock, place in silo, or destroy by burning.

Cut and remove field corn from the field as soon as the ears are mature. Feed the stalks to live stock as soon as possible and burn or otherwise dispose of the uneaten parts before May 1 following. Shred or cut the fodder to increase its consumption.

Plow under thoroughly in the fall all infested cornstalks, corn stubble, other crop remnants, weeds, and similar material which it

is impractieal to destroy in any other manner. When necessary to adopt this praetiee, an attempt should be made to plow under ALL of the material to a depth of at least 6 inches.

Plant small areas of early sweet corn to act as a trap crop adjacent to the fields intended for field eorn or late sweet eorn. Feed or otherwise destroy this early sweet eorn as soon as the ears are harvested, or preferably just before that period, if the grower is willing to saerifice the ears. Such plantings, where not destroyed at the proper time, eonstitute a menace to later corn.

Limit the size of cornfields to areas that can be kept free of weeds.

Do not plant corn within 50 feet of beets, beans, eelery, spinaeh, rhubarb, or flowering plants intended for sale.

Do not throw the uneaten parts of eornstalks used as feed or bedding into the manure pile unless this material is worked into piles containing enough fresh horse manure to produce heating.

Do not transport outside of the infested area any of the plants or plant products listed on page 32.

Do not transport alive, in any of its stages, specimens of the European eorn borer outside of the infested areas.

Do not place in swill container any sweet-eorn ears or portions thereof, or discarded portions of celery, beets, beans, rhubarb, and spinach when this material is suspected of eontaining the borer.

Do not dump cornstalks or other plant refuse from the vegetable and flower garden on public dumps or on the edge or flood level of brooks, rivers, and other bodies of water.

Do not attempt to circumvent the quarantine regulations. The penalty is severe.

Do not mix products grown within the infested area with those grown outside the infested area.

Do not label packages containing flowers or other produets with misleading statements of eontents.

Do not pack produee in boxes or other eontainers until all old tags and permits have been removed.

Do not feel angry if produets are confiscated at State or international border lines for violation of quarantine regulations. Such action is the most lenient that may be taken under the law.

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